FUEL REFORMULATION AND EMISSIONS IN EUROPE AND JAPAN

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A. Introduction

In the drive for a cleaner environment of the transportation sector not only the vehicles,but also the fuels are studied for further improvements. Europe and Japan are no exceptions,although in motorgasolines the US is clearly leading.
While diesel is only 17% of US motor fuels,it is more important in Europe,Japan and the rest of the world with some 45%-plus,and so is its reformulation.

Recently an extensive European Oil/Auto test program,called EPEFE has been completed in order to decide on new "Europe-wide"specs. for both diesel and motorgasolines.
Later this year the European Commission and Parliament will decide on the specifics,the time schedule etc. after having heard all parties concerned.

Much earlier work and study has preceded this;but in the final judgement both any extra CO_2 and costeffectiveness will be considered,plus special local problems (big cities:Milan,Athens,etc.)

CONCAWE, the "Oil Companies' European Organization for Environment,Health and Safety", established in 1963,has played as important role in this and earlier test programmes as well as ACEA (Auto Co's) and national institutes active in the collective interest.

The Japanese situation,on-the-ground at least as difficult as southern Europe/California,is different:

- --Tight regulations on emissions,
- --A severe testing schedule,and young vehicle population,
- --Good fuels,see later.

Their extensive statistics,reporting "road-side SOx and -NOx" demonstrate the results of their efforts.As in Holland and Germany SOx and HC are coming down, but NOx stays high. Because yes,we all are driving more and more using ever more motor fuels!

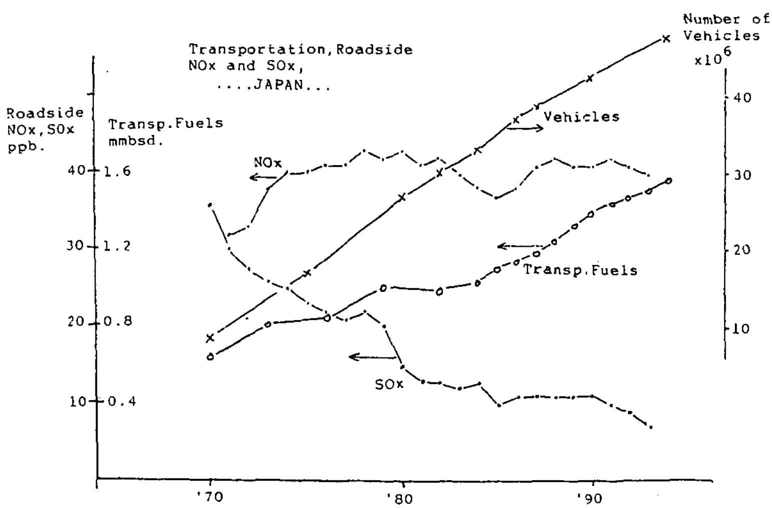

fig.1

B . Diesel Fuel Studies in Europe

During the last decade the improvement of diesel engines and fuel has been high on the agendas of both manufacturers and refiners. Like in gasoline,most progress has been made in engine design,and most recently,with catalytic soot filters.

In the recent past CONCAWE had already shown that:

a) The Cetane Number is the most important parameter for most emissions; much more than Density,Aromatics,and T90. The latter have varying effects of some 5% at best within the limits of commercial interest.
b) Catalytic filters are able to reduce CO/HC/PM by some 20-25%, moreover all fuel effects become smaller,see lit.2&3.

The European Programme on Emissions,Fuels and Engine Technology, EPEFE,described above, had selected for experiments those areas that had not been covered sufficiently earlier or elsewhere in the US and Japan.
An outstanding feature of their recent series is the use of engines with "year 2000"-technology, so not today's engines.
This choice shows clearly in the level of emissions,Table 1,in particular the low HC/CO/PM -values. They could even be comparable to California TLEV 's.

However,in these vehicles the effects of variations in diesel-properties ,even over a wide range are limited,see table no 1. When comparing the results in Light Duty and Heavy Duty vehicles table 2, the plusses and minusses do not even match always, so a "Solomon's Judgement" is needed!

Table 3 gives the principle characteristics of the average diesel fuels of the US,Japan and Europe,plus some of the "talked about" changes in specs,which now have entered the environmental-economic-political arena in Brussels.
The costs of diesel reformulation has been calculated for several scenarios by CONCAWE,lit.5;table 6 has been derived from a still "modest" scenario. A cetane spec.change to 58 min indeed looks unlikely seen the costs of widespread deep aromatics hydrogenation and the extra energy-to-CO_2!

C. Motorgasolines Studies,Europe

With all the work done in this particular area in the US and the results of actions in California,the EPEFE program has only tried to fill in some blank spaces because of the different car population,and the speedier driving habits: the European tests are now containing a 120 km/hr. section.
Here also cars with "yr-2000" engines have been used, which shows up in their low av. emissions. One car has such a good,flexible air:fuel ratio controler that its NOx is 0.07 g/km for all fuels. Its other emissions were also so low that no fuel quality effects could be detected! Table 4 has the results of this section of the recent European tests. Earlier US conclusions regarding Sulphur were confirmed;all other parameters gave "plusses & minusses"

Although the general feeling is strongly in favor of "one percent Benzene max,these and other health risk studies suggest this is not necessary now and in the nearby future.

Table 5 compares the average values of motor gasoline inspections of the US,Japan and Europe.(only some essential items)
The octanes are slightly higher in Europe,even of the lead-free grades. All new cars are designed for RON/MON=95/85.
Re-setting the specs to the values "talked about" will have enormous consequences for the refining industry.
A "reg-neg" process,as in the US,leading to Simple and Complex models is not feasible in Europe. A gradual introduction of new specifications,allowing the industry time to invest,both the auto makers and the refining side,is most likely.

Table 6 summarizes the costs of the above depicted targets of reformulation of both gasoline and diesel fuel: virtually every refinery will need new equipment,particularly hydrocrackers and hydrotreating/hydrogenation units. (from lit.5)

In Japan a further study as a result of the "1995 White Paper on the Environment" is expected to lead shortly to new legislation. However, an increasing part of acid rain seems to come from the rapidly developing neighboring countries!

D. Concluding Remarks

--Reformulation of motorfuels in Europe is now under general scrutiny; tighter specs on both diesel and gasoline are expected, rather than "complex or simple models".

--Major improvements can only be expected from new engine- and exhaust treatment technology; first indicationsare that also here some 10% reduction of emissions can be obtained from so-called cleaner fuels.

--NOx from diesel engines could be the remaining problem; a catalytic solution is highly desirable! (See lit.6)

Literature:

1--Petroleum Industry in Japan,1995, by "The Japanese Committee for World Petroleum Congresses"(fax +81-3-5395-5384)

2--Concawe Report no.92/54

3-- " " no.94/55&56

4--EPEFE report, Diesel Project, WEFA conf.'95 .M.Hublin

5--Concawe Report no.95/54

6--Motor Vehicle Pollution, Reduction Strategies beyond 2010. OECD-publication 1995. Paris.

TABLE 1
Diesel Reformulation Test results
European -EPEFE test program with
"Yr.-2000 engines and catalysts"

	CO	HC	NOx	PM
A Light Duty Vehicles	----------grams per km.----			
-- Emissions level of testvehicles	0.45	0.10	0.55	0.06
-- Vehicle Euro-specs. '95/'96	2.1	0.25	0.62	0.12
California TLEV	2.1	0.15	0.3	0.08
-- Major Improvements by Reformulations %	25[3]	25[3]	3.4[2]	19[1]
B Heavy Duty Vehicles	--------grams per KWh-----			
-- Test vehicle level	0.59	6.3	3.6	3.6
-- Euro-specs.	4.0	1.1	7.0	0.15
-- Calif.'94 level	11.0	1.0	6.7	0.11
-- Major Improvements by Reformulation %	10[3]	6.3[3]	3.6[1]	3.6[2]

C. Fuels Programme:

1)Density decrease: 0.855 to 0.828
2) Poly Aromatics%: from 8 to 1%
3)Cetane Number : " 50 to 58
4) T-95,degrees C : 370 to 325

TABLE 2
Comparison of effects of fuel properties
..Light and Heavy Duty Vehicles...

		CO	HC	NOx	PM
DENSITY	LD*	-17.1%	-18.9%	+1.4%	-19.4%
855-828 kg/m3	HD**	+5.0%	+14.3%	-3.6%	-1.6%**
poly-aromatics	LD*	+4.0%	+5.5%	-3.4%	-5.2%
8-1%	HD**	-0.1%***	-4.0%	-1.7%	-3.6%
cetane number	LD*	-25.3%	-26.3%	-0.2%***	+5.2%
50-58	HD**	-10.3%	-6.3%	-0.6%	-0.1%***
T95	LD*	-1.8%***	+3.4%***	+4.6%	-6.9%
370-325 deg C	HD**	+6.6%	+13.4%	-1.7%	0.0%***

- * ECE+EUDC cycle
- ** ECE R49 13-mode cycle
- *** Statistically non significant

TABLE 3

Average Properties of Diesel Fuels
(excl. color,cold flow,stab.etc.)

	US	JAPAN	EUROPE	Changes "Talked-about"
Density,g/ml	0.848	0.838	0.840	"down"
Aromatics %	30	23	25	25 max.
Poly- Arom.%	-	-	4-6	?
Cetanes:				
-number	46	55	51	55 min.
-index	47	57	53	-
Sulphur ppm	----------500 max--------			"down"?
T20 C	240	240	215	-
T50 C	270	260	265	-
T95 C	315	345	360	?

TABLE 4

Motor Gasoline Reformulation Europe,
Results of the recent EPEFE test programme

	CO	HC	NOx
	---------grams/km -------		
Test Vehicles used, "Yr. 2000 technology"	1.41	0.16	0.18 a)
Euro/EFTA-specs.	2.0	0.25	0.12
California TLEV	2.1	0.16	0.62
Japan '94	2.1	0.15	0.24

Maximum Improvements:

1) S from 400 to 20 ppm : all emissions down 10%!
2) Aromatics from 50% to 20% : CO/HC down 10%: NOx up 10%.
3) E100°C 60% to 40% : no effect.
4) T90 °C 185 to 165 : CO/HC down 5%: NOx,see 2); no change.
5) Benzene 2.5%-0.95% : down from 5% to 3,5% in HC emitted.

a) One vehicle,with a new very good A-F ratio controler tested 0.07 g NOx per km!

TABLE 5

Typical Properties -Motor Gasolines '94
.....Averages,Summer.....

	US Baseline '90	US RFG-II	JAPAN	EUROPE
RVP. psi	7.8	6.7	8	7-9
Sulphur,ppm	338	140	40	300
Oxygen %	-	2.1	0.5	0.6
Aromatics %	28.6	25	30	35
Olefins %	10.8	12	16	12
Benzene %	1.6	0.95	2.5	2.1
RON/MON	-----95/84-----		94/84	96.5/86
T50 °F	207	200	204	200
T90 °F	332	313	300	320
E200°F,vol %	46	49	51	45
E300°F,vol %	83	87	91	84

"Europe" may reduce in) stages the following)-- items:)

Sulphur	to	100 ppm max.
Aromatics	to	25 % max.
Olefins	to	10 % max.
Benzene	to	1 % max.
Oxygen	to	1.5% min.

TABLE 6

Economic Impact of Reformulation
of Gasoline and Diesel-- Europe.
(Concawe Report no.95/54,yr.2000)

A) Diesel - quality,appr.table 3;200 ppm S; 100×10^6 tons/yr.

	Capital charge	All other op.costs	Total	Extra CO_2 from Refining, kg/ ton
	------------$/mTon--------			
Cetane No. =55	15	5.5	20.5	50
Cetane No. =58	20	19	39	350

Compare with the late '95 prices of av. diesel fuel:
..in bulk ,tax free: $/ton 170
..at the pump,
incl. all taxes : " 700-1200

B) Motor Gasoline -quality table 5; quantity 125×10^6 tons/yr.

Capital Charge,excl.for MTBE: $/ton.. 16
Other fixed & variables " .. 6
" 22+

Compare with:..'95 market price, excl. taxes: $/ton 200
"At-the pump" incl. taxes...: " 1200-1500!